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THE PROBLEM OF HEREDITY.

A Critique of the Theory of Evolution. By Prof. T. H. Morgan. Pp. x+197. (Princeton: University Press; London: Oxford University Press, 1916.) Price 6*s.* net.

THE title of this little volume of four lectures delivered at Princeton University is likely to cause some disappointment. The book is almost entirely an exposition of certain facts as to inheritance ascertained by experiments with the fruit-fly, *Drosophila ampelophila,* and "a review of a long series of researches as to the nature of the hereditary material." The author claims that "the mechanism of heredity has been discovered" and that "the problem of heredity has been solved." He holds that "the mechanism of the chromosomes offers a satisfactory solution of the traditional problem of heredity."

Whilst all credit is due to Prof. Morgan for his long and careful investigations—which have been published elsewhere and are here summarised with excellent diagrams—it cannot be admitted that the demonstration of the numerical relations of the chromosomes distributing to the germ-cells the hereditary factors carried by the parents is of the importance which he supposes. The "traditional problem of heredity" cannot be correctly described as limited to the inquiry as to what are the carriers of the factors of heredity and their relations to one another as carriers. The questions as to *how* the factors arise and *how* they influence the development of the embryo cannot, as Prof. Morgan somewhat arbitrarily states (in so many words), be excluded from a solution of the real, traditional, and actual problem of heredity. The fact seems to be that the knowledge of what is called "Mendelian inheritance" and the relation to it of the chromosome mechanism does not take us much further into the "problem of heredity" than we had already got when, after Darwin had stated the facts known to him and the views they suggested in his "Animals and Plants under Domestication," Edouard Van Beneden and other histologists first unravelled the chromosomes and gave us the classical records of their visible activity in fertilisation.

We have not got much further since those days, but there is no doubt that some facts of interest have been added to the stock of knowledge by those who have confirmed Mendel's experiments. When we look to the present summary for some statement of what important progress in our conception and understanding of inheritance is to be reported, we are reluctantly driven to the conclusion that what Prof. Morgan calls "a satisfactory solution of the traditional problem of heredity" is only a restatement of the problem in terms of invisible "factors" associated with the chromosomes. The existence of such "factors" is not a new inference, but has been a feature of theories of inheritance both before and since Darwin's treatment of the subject. Mendel contributed to knowledge the solid fact that in certain easily observed cases (if not universally) a pair of opposed or contrasted factors—present one in one parent and one in the other—do not really "blend" in cross-breeding, but in successive in-bred generations of the hybrid offspring (of intermediate or mixed character) become separated out in two pure races, each identical, so far as the factor selected for study is concerned, with one of the original cross-bred parents. That observation and its extensive confirmation are important steps in the study of the nature, origin, and possibilities of the "factors." So also is the demonstration of their close association with the chromosomes, which was suggested as soon as the activity of those structures in the process of fertilisation was first observed.

This is, however, only a beginning: it remains to be seen how far the application of these results to the actual facts of inheritance as stated by Darwin in the successive chapters of his "Variation of Animals and Plants under Domestication" helps us to explain or understand those facts. So far the application has not been made—so as to obtain any result beyond a restatement of the facts in other terms and language—nor does there appear to be any immediate prospect of progress in that direction.

An important suggestion is made by Prof. Morgan, namely, that the "factors" themselves may vary or fluctuate. He says: "I do not know of any *a priori* reason why a factor may not fluctuate, unless it is, as I like to think, a chemical molecule." He, however, proceeds to give evidence opposed to such fluctuation.

It seems that the line of investigation pursued by Prof. Morgan and other recent experimenters who have developed Mendel's original observations into an imposing volume of detail has disappointed expectation. It will, we believe, be of service, but it has, to the regret of all, not led into the fruitful region anticipated by those who entered upon it with so much enthusiasm and energy. In order to gain a deeper understanding of the many remarkable facts of organic heredity a new departure is necessary, new inductions suggesting new and untried lines of observation and experiment.

So far as the title of these lectures, "A Critique of the Theory of Evolution," is concerned, there is very little said in them which justifies it. Prof. Morgan objects to the use of the word "evolution" as employed by Herbert Spencer, on the ground that it is "rather an empty generalisation to say that any kind of change is a process of evolution. . . . What has," he asks, "the evolution of the stars, of the horse, and of human inventions in common?" This seems to be somewhat unnecessary, since no one has said that "*any* and *every* kind of change is a process of evolution," and the instances of evolution which he cites have, as such, well-recognised features in common. Attempts to correct flagrant misuse

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of words are often of great value; but a writer may bring his own qualities of judgment and understanding into discredit by erroneously supposing that a misuse requires correction where no such misuse exists.

We are also unable to admit the validity of Prof. Morgan's assimilation of the "artificiality" of the conditions under which humanly selected breeds are produced and studied to the "artificiality" of a spectroscope or a galvanometer (p. 84). The justification for reserve and caution in generalising in the former case is not that these breeds are "artificial," but that the essential and significant conditions of the phenomena they present are not clearly ascertained, whilst in regard to the instruments known as spectroscope and galvanometer those conditions are accurately established.

The point of greatest interest at the present moment in a critique of the theory of organic evolution by a capable and accomplished investigator of the facts of inheritance—such as Prof. Morgan—is his answer to the question: "Does natural selection influence the course of evolution?" (p. 187). Prof. Morgan gives a very carefully worded answer in the affirmative. He says: "If through a mutation a character appears that has a *beneficial* influence on the individual, the chance that the individual will survive is increased, not only for itself, but for all of its descendants that come to inherit this character. It is this increase in the number of individuals possessing a particular character that might have an influence on the course of evolution." He goes on to say: "The causes of the mutations that give rise to new characters we do not know, although we have no reason for supposing that they are due to other than natural processes. Evolution has taken place by the incorporation into the race of those mutations that are beneficial to the life and reproduction of the organism. Natural selection as here defined means both the increase in the number of individuals that results after a beneficial mutation has occurred (owing to the ability of living matter to propagate), and also that this preponderance of certain kinds of individuals in a population makes some further results more probable than others. More than this natural selection cannot mean, if characters are fixed and are not changed by selection."

We do not know of anyone who maintains that factors are changed by selection. Darwin certainly did not make such a misuse of the word "selection." But there is a great field of inquiry still to be undertaken which is indicated by the words "if factors are fixed." We are a long way from possessing knowledge that would justify the conclusion that they *are* fixed—as Prof. Morgan is careful to point out (p. 166). Darwin held that they are subject to influences which cause them to vary, and it is by research in this area that we may hope for future advance in the understanding of the complex web of the phenomena of heredity.

E. RAY LANKESTER.

GENERALISED CO-ORDINATES.

An Introduction to the Use of Generalised Co-ordinates in Mechanics and Physics. By Prof. W. E. Byerly. Pp. vii+118. (Chicago and London: Ginn and Co., 1916.) Price 5*s.* 6*d.*

THIS work is sure to be welcomed, because Prof. Byerly has undoubtedly the gift of appealing successfully to the average student. More than that: in its small compass it includes a wide scope because, starting with the notion of generalised co-ordinates in its abstract analytical form, it proceeds to the discussion of such things as the Hamiltonian equations, the principle of least action, the ignoration of co-ordinates, and the proper use of the modified kinetic-energy function. For a teacher the book is cheap, if only for the example (*d*) on p. 21, and the subsequent discussion of the same example on pp. 98–103. We have not seen a more illuminating example within the range of an ordinary student; it shows admirably the difference between abstract dynamics, where all necessary data are provided, and practical physics, where the data are experimental, and need by no means correspond with the actual elements of the problem. In this case it is a question of guessing at the simplest explanation of an unseen "control" of a mechanism on which we can make experiments within a certain range.

Among the many merits of this book we may signalise the following: the examples are almost all instructive and free from artificiality; we have some where the same result is obtained by different advanced methods—for instance, pure Lagrange, pure Hamilton, and Hamilton *plus* Routh (with a modified function), and these are compared with previous solutions by elementary methods. As a matter of notation, we may direct attention to the symbol $M_{q,r}$ for the energy-function modified with respect to the position-co-ordinates q, r. The meaning of partial derivatives is so variable in this connection that we should like such symbols as $T(q^2)$, $T(p^2)$, $T(pq)$ introduced throughout for the velocity-forms, momentum-forms, and "mixed" forms of T whenever there is any risk of confusion. The fact that, *in a certain sense,* the Lagrangian function L means $T-V$ (strictly $T(q^2)-V$), and the Hamiltonian function means $T+V$ (strictly $T(p^2)+V$), is extremely baffling to a beginner. In particular, the "canonical" equations of Hamilton imply a special representation of the energy-function.

Prof. Byerly's book is so good that it deserves a much more searching criticism than the present reviewer can pretend to give; but a few remarks may be ventured here. The example (p. 18) about the dog running down a plank is all right as it stands, but it tacitly implies that the dog is reduced to a mere machine applying a constant frictional force to the plank parallel to the inclined plane. Students who try to solve "animal" problems by Lagrange's method may make some fearful howlers. Another point (p. 72) is the question how far we can treat ω_1, ω_2, ω_3 occurring

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